Association of foods consumption and physical activity with prefrailty and frailty among Chinese older adults in urban communities: A cross-sectional study

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ABSTRACT

Background and Objectives: Frailty has become a public health challenge in China. To investigate the association of foods consumption and physical activity with prefrailty and frailty among older Chinese adults in urban communities. **Methods and Study Design:** In a cross-sectional study from February to July 2023, 1183 older adults aged between 65y-88y were enrolled from urban communities in Chongqing and Shandong province, China. Frailty Index (FI) was applied to measure prefrailty and frailty. Partial proportional odds model was used to assess the association between foods consumption, physical activity and prefrailty/frailty. **Results:** Higher Dietary Diversity Score (DDS), (OR=0.61, 95% CI=0.46-0.80; OR=0.47, 95% CI=0.28-0.79), Consuming animal-based foods ≥2 times/day (OR=0.62, 95% CI=0.47-0.82; OR=0.54, 95% CI=0.33-0.88), soy products ≥2 times/week (OR=0.69, 95% CI=0.53-0.89; OR=0.51, 95% CI=0.31-0.84), fresh vegetables ≥2 times/day (OR=0.42, 95% CI=0.31-0.57; OR=0.41, 95% CI=0.23-0.72), and nuts ≥2 times/week (OR=0.71, 95% CI=0.55-0.91; OR=0.52, 95% CI=0.32-0.85) was associated with a lower risk of prefrailty and frailty. In addition, higher frequency and longer duration of walking (OR=0.61, 95% CI=0.42-0.88; OR=0.63, 95% CI=0.48-0.81), exercise (OR=0.48, 95% CI=0.35-0.64; OR=0.44, 95% CI=0.32-0.61) per week were significantly associated with lower risk of prefrailty. Furthermore, higher frequency and longer duration of walking (OR=0.42, 95% CI=0.25-0.72; OR=0.46, 95% CI=0.29-0.74), and housework (OR=0.39, 95% CI=0.24-0.65; OR=0.57, 95% CI=0.34-0.96) per week, were significantly associated with lower frailty. **Conclusions:** Higher DDS and higher frequency of animal-based foods, soy products, fresh vegetables, and nuts consumption is significantly associated with lower risk of prefrailty and frailty. Conversely, Higher frequency of salted products and fried food consumption is positively associated with the risk of prefrailty. Additionally, walking and exercising are significantly associated with lower risk of prefrailty, while walking and doing housework is significantly associated with lower frailty.

Key Words: frailty, frailty index, food group, physical activity, community-dwelling older people

INTRODUCTION

In recent years, the global aging population has been on the rise, with China leading the world in its elderly population.[1] By 2040, the number of people aged 60y and above is expected to reach 402 million.[1] This demographic shift brings with it a significant public health challenge:

frailty.[2] Frailty is a condition marked by a physiological decline in organ systems, leading to decreased resilience to stressors and a heightened risk of negative outcomes such as falls, hospitalizations, disability,[3] and even death.[4] Frailty not only affects older individuals, but also results in increased medical and long-term care expenditure for both family and society.[5] Frailty Index (FI) is an approach that accumulated the number of health deficits to assess frailty[6] which has been demonstrated to be a stronger predictor of mortality among older adults.[7] Nevertheless, frailty is a dynamic state that exists before occurrence of disability and can be prevented, postponed or even reversed.[8,9] Diet and physical activities appear to play a major role in its development,[10] making nutrition and exercise recommendation more crucial for modifying the risk factors associated with frailty.

Several studies have indicated that macronutrients, food group, and dietary patterns are associated with frailty. In particular, previous studies have demonstrated the significant role of protein intake (>1 g/kg BW/day) in reducing the prevalence of frailty.[11] Additionally, they have highlighted the importance of consuming ample amounts of fruit and vegetables (>5 servings/day) in lowering the risk of frailty.[12] Furthermore, adherence to the Mediterranean diet has been found to be effective in decreasing the risk of frailty.[13] Despite many investigations on frailty phenotype,[14] there remains a notable paucity of studies examining the FI and its correlation with nutritional factors. The intricate nature involved in constructing the FI has indeed contributed to the existing gap in the literature.

In addition, given the substantial disparities in culture, variety of food, and dietary behaviors observed across different countries and regions, there exists a compelling need to explore the interrelation between the oriental diet and both prefrailty and frailty. Moreover, many older adults in China consume more soy products and less dairy products than in other countries.[15,16] In recent 20 years, with rapid improvement of living standards and healthcare services, the diet transition is significantly in China, especially for older adults living in urban area.

Up to now, there still exists significant gap in understanding the relationship between changeable factors and FI among older Chinese adults. Thus, this study aims to bridge this gap by exploring the association between major food group consumption frequency and physical activity frequency and duration with the risk of prefrailty and frailty among older adults in urban Chinese communities.

MATERIALS AND METHODS

Study population and design

This cross-sectional study was conducted from 27th February to 19th July 2023 using the convenience sampling method. A total of 1183 older adults aged from 65y to 88y were recruited from Maoershi Primary Healthcare Institution in Jiangbei district, Chongqing, and Shengdong Hospital in Dongying, Shandong province. Eligible participants were community-dwelling individuals aged over 65 years. Exclusion criteria were applied: (1) Any disability that affects daily activities or physical measurements; (2) Any communication barriers or impediments to investigation, such as deafness, severe mental disorder; (3) Under 65 years old. The study was undertaken according to the guidelines laid down in the Declaration of Helsinki. All participants signed an informed consent before the enrollment. All procedures involving human subjects were approved by the Ethical Committee of National Institute for Nutrition and Health (NINH), Chinese Center for Disease Control and Prevention (NINH 2022-036).

Prefrailty and frailty assessment

The validated FI for older Chinese was used. This tool was formulated following a standard procedure[17] based on a comprehensive geriatric assessment scale (CGA-Scale), as described previously.[18,19] The FI is composed of 37 variables, including comorbidity (based on self-reports of diagnosis by doctor, n=14), hospitalization (n=1), geriatric syndrome (n=11), physical function (n=1), cognitive function (n=1), depression (n=1), malnutrition (n=3) and sarcopenia (n=5). The FI is calculated as the number of deficits present in a person divided by the 37 deficits for each participant (Supplemental Table 1), thus it is a continuous variable that ranges from 0.00 to 1.00, with higher values reflecting severity and vulnerability. According to general reference, we categorized the FI into three levels of frailty status: robust (FI<0.20), prefrailty (FI ≥0.20 to <0.35), and frailty (FI ≥0.35).[20]

Other variables

Data for sociodemographic characteristics (e.g., age, gender, level of education, and marital status), personal medical history (e.g., coronary heart disease, hypertension, and cardiac failure), sleeping habits, mental status (i.e., cognition and depression), dietary and lifestyle factors (e.g., food group consumption frequency, alcohol history, tobacco smoking history, dietary supplements or not, physical activity frequency and duration) were collected by trained staff by face to face interview with paper questionnaire. Physical measurements

including weight, height, waist, 5-time chair stand test, gait speed, calf circumference, handgrip strength were recorded by use of calibrated instruments and following standard procedures.[21] Calf circumference was measured the maximum value of both calves using a nonelastic tape. Handgrip strength was assessed in a standing position with a grip strength meter (CAMRY EH101, Xiangshan, Zhongshan, China) and performed the maximum strength twice with both hands.[22] The indexes of body composition were measured by the Inbody 770 device (Biospace, Seoul, Korea). Dietary diversity was calculated by The Dietary Diversity Score (DDS) developed by Kant et al.[23] Physical activity level was calculated based on Metablic Equivalent (MET) and classified into three level: low (MET < 600), moderate (600≤MET≤3000), or high (MET > 3000). [24]

Statistical analysis

Quantitative data were reported as mean and standard deviance (SD). Comparisons three order groups were performed using the Wilcoxon test. Categorical data were presented as number and percentage. Partial proportional odds model was employed to analyze the relationships between major food group consumption frequency and both prefrailty and frailty. Quantitative data (food group consumption frequency, physical activity frequency and duration) was categorized by P50.The lowest consumption frequency was defined as a reference, and odds ratios (ORs) and 95% confidence intervals (CIs) were calculated in different models. Model 1 was adjusted for age and gender, while model 2 was adjusted for age, gender, education, marital status, living alone, profession before retired, pension income, drinking history, smoking history, dietary supplements. All covariates were coded as dummy variables before the adjustment. Statistical analyses were performed using SAS 9.4 (SAS Institute, Cary, NC, USA). A significance level of $p<0.05$ was considered statistically significant.

RESULTS

General characteristics

A total of 1183 subjects were included in the analysis after applied the exclusion criteria. The prevalence rate of frailty was 6.9% (81/1183), 6.2% (36/584) in male and 7.5% (45/599) in female. The prevalence rate of prefrailty was 39.1% (462/1183), 32.5% (190/584) in male and 45.4% (272/599) in female. 25.9% (306/1183) are older than 75 years old, 90.8% (1074/1183) have a secondary school education or below, 157 are unmarried or widowed (13.3%), 89 live alone (7.5%), and 666 (56.3%) have a pension income of less than RMB 4,000. (Table 1).

Frequency of weekly consumption of foods consumption and physical activity in robust, prefrail and frail

There were significant differences in the weekly intake frequency of cereals, coarse cereals, animal-based foods, soy products, salted products, nuts, and fried foods among patients with different frailty states. With the severity of frailty, the weekly intake frequency of cereals, animal-based foods, soy products, dairy products, and fried food decreased, while the intake frequency of coarse cereals and salted products increased (p<0.05). (Table 2)

There were significant differences in the frequency of weekly physical exercise, social activities, and housework among patients with different levels of frailty. Lower frequency of weekly physical exercise, social activities, and housework significantly with the severity of frailty (p<0.05). There were significant differences in the time of weekly walking, physical exercise, social activities, and housework among patients with different levels of frailty. Decreased time of weekly walking, physical exercise, social activities, and housework significantly with the severity of frailty (p<0.05). (Table 3)

Association of foods consumption and physical activity with prefrailty and frailty

The findings revealed a negative associations between a higher DDS, a higher frequency of animal-based foods (≥2 times/d), soy product (≥2 times/wk), fresh vegetable (≥2 times/d) and nuts consumption (≥2 times/wk) and frailty severity at a significance level of 0.05.

Upon adjusting for age and gender, significant associations were observed between higher frequencies of animal-based foods (≥2 times/d) (OR=0.57, 95% CI=0.43–0.74), soy products (≥2 times/wk) (OR=0.69, 95% CI=0.54–0.89), fresh vegetable (≥2 times/d) (OR=0.60, 95% CI=0.46–0.80), fruits (≥1 time/d) (OR=0.67, 95% CI=0.51–0.88) and nuts consumption (≥2 times/wk) (OR=0.73, 95% CI=0.57–0.93) with a reduced risk of prefrailty. Conversely, higher frequencies of salted products (≥1 time/wk) (OR=1.36, 95% CI=1.06–1.74) and fried food (>0 times/wk) (OR=1.48, 95% CI=1.15–1.91) were associated with an increased risk of prefrailty. Similarly, significant associations were found between higher consumption of animal-based foods (≥2 times/d) (OR=0.50, 95% CI=0.31–0.80), soy products (≥2 times/wk) (OR=0.58, 95% CI=0.36–0.92), and nuts consumption (≥2 times/wk) (OR=0.58, 95% CI=0.36–0.93) and a lower risk of frailty. Further adjustments for education, marital status, pension income, drinking history, smoking history, dietary supplements, physical activity level revealed significant associations between higher frequencies of coarse cereals (≥1 times/d) (OR=0.63, 95% CI=0.48–0.82), animal-based foods (≥2 times/d) (OR=0.62, 95% CI=0.47–0.82), soy product (≥2 times/wk) (OR=0.69, 95% CI=0.53–0.89), fresh vegetable

(≥2 times/d) (OR=0.42, 95% CI=0.31–0.57), fruits (≥1 time/d) (OR=0.64, 95% CI=0.48–0.85) and nuts consumption (≥2 times/wk) (OR=0.71, 95% CI=0.55–0.91) with a decreased risk of prefrailty. Additionally, a higher consumption of salted products (≥1 time/wk) (OR=1.30, 95% CI=1.00–1.68) and fried food (>0 times/wk) (OR=1.41, 95% CI=1.08–1.84) was associated with an elevated risk of prefrailty. Notably, significant associations were observed between higher frequencies of animal-based foods (≥2 times/d) (OR=0.54, 95% CI=0.33–0.88), soy product (≥2 times/wk) (OR=0.51, 95% CI=0.31–0.84), fresh vegetable (≥2 times/d) (OR=0.41, 95% CI=0.23–0.72), tea (≥1 time/d) (OR=0.55, 95% CI=0.33–0.92) and nuts consumption (≥2 times/wk) (OR=0.52, 95% CI=0.32–0.85) with a reduced risk of frailty (Figure 1).

Both Model 1 and Model 2 demonstrated a significant association between higher frequency of walking (≥1 time/d), exercise (>0 times/wk), and housework (>2 times/d) and a reduced risk of prefrailty, while a higher frequency of walking (≥1 time/d) and housework (>2 times/d) was significantly linked to a decreased risk of frailty ($p<0.05$). We also found that longer duration of weekly outdoor activity (≥420 min), walking (≥420 min), exercise (>0 min), were significantly associated with a decreased risk of prefrailty. Furthermore, longer duration of weekly outdoor activity (≥420 min), walking (≥420 min), exercise (>0 min), and engagement in household chores (≥630 min) were significantly associated with a reduced risk of frailty ($p<0.05$) (Figure 2).

DISCUSSION

We found the prevalence of frailty was 6.9%, and prefrailty was 39.1% among the participants aged 65 years and older, and a higher prevalence of frailty in women than in men.[25] Our findings align with a meta-analysis of 14 studies involving 81,258 Chinese adults aged 65 years and older in the community, which reported a similar prevalence of prefrailty (40%, 95% CI=37-50%) and frailty (10%, 95% CI=8-12%).[26] A systematic review presented that the prevalence of prefrailty and frailty in Germany was 40.2% (95% CI=28.3-52.1%) and 13.7% (95% CI=9.0-18.5%) respectively.26 In Japan, the prevalence of prefrailty and frailty was 48.1% (95% CI=41.6%-54.8%) and 7.4% (95% CI=9.0-18.5%), respectively.[27] In addition, the distribution of FI in our study is right-skewed, which is similar to those in previous studies.[28]

There was a significant association between high DDS (≥12) (OR=0.61, 95% CI=0.46-0.80; OR=0.47, 95% CI=0.28-0.79 respectively) and lower prefrailty and frailty. A cross-sectional study in Taiwan showed that older adults with cognitive prefrailty or cognitive

frailty were associated with lower DDS. Those with prefrailty or frailty and lower DDS demonstrated a higher cognitive impairment risk (adjust OR=2.15, 95% CI=1.21-3.83) than those without frailty and higher DDS.[29]

Numerous elderly individuals worry that increasing their consumption of animal-based foods may increase the likelihood of developing chronic conditions such as cardiovascular and cerebrovascular diseases.[30] Consequently, they decease intake of meats and even endorse vegetarian diets. However, our research indicates that individuals who consume animal-based foods ≥2 times/day exhibit a lower risk of frailty in compared with those who consume less than twice a week. Notably, our FI incorporates deficits associated with 14 chronic ailments, including cardiovascular and cerebrovascular diseases. Previous studies have consistently shown that higher protein consumption is associated with a reduced risk of frailty.[31] A meta-analysis showed that a high protein intake (≥1.0 g/kg BW/day) and very high protein intake (≥1.2 g/kg BW/day) were associated with improved lower-limb physical performance when compared to low protein intake(<0.8 g/kg BW/day).[32] Another prospective study in Newcastle found that consuming ≥0.8 g/kg BW/day and ≥1.0 g/kg BW/day of protein significantly decreased the incidence of frailty from 85-90 years.[33] Additionally, several studies also demonstrated that seafood was negatively associated with frailty.[34] It might because that animal-based foods contain more protein enriches in higher content of essential amino acids (EAAs) and branched-chain amino acid (BCAAs),[11] which played an important role in the anabolic response and muscle anabolism.

Our findings show that higher frequency of soy product consumption is negatively associated with frailty. Some studies indicated that soy protein exerts distinct anti-inflammatory properties which might further reduce the risk of frailty. For instance, soy protein supplementation leads a significant reduction of serum Tumor Necrosis Factor Alpha (TNF-α), while the addition of isoflavones exhibited further benefits by reducing serum C-reactive protein (CRP).[35] In addition, some evidence suggested that soy-based diets could reduce the risk of several chronic diseases.36 However, the research on association between soy products and frailty is insufficient. A study in Japan showed that there was no significant association between soy products and the Kihon-Checkist frailty incidence.[34] Our findings provide evidence that soy products are negatively significantly associated with prefrailty and frailty in Chinese older adults.

According to Lochlainn et al's review, the evidence regarding the association between milk and dairy consumption and frailty remains insufficient.[37] A recent prospective study in Japan has reported positive effects of dairy consumption for older adults. The study elaborated that

higher intake of dairy (114g/d) was negatively associated with prefrailty or frailty over a two-year follow-up period, even after adjusting for age, gender and other covariates.[38] Another study carried out among an older community-dwelling Spanish population showed that greater consumption of low-fat milk and yogurt was associated with lower risk of frailty, but there was no association with full-fat dairy product consumption after 3.5 years of follow-up.[39] In our study, we did not find significant association between the frequency of dairy products consumption and frailty. This may be attributed to three factors. Firstly, dairy consumption in older Chinese is notably lower than that in Europe (41.1 vs. 182.3 kg/year in 2020).[16] Therefore, comparing with older Europeans, older Chinese obtain less nutrients such as high quality protein, from dairy products. Secondly, a previous study reported that the proportion of elderly individuals in China who regularly consume dairy products tends to increase with age.40 Thirdly, we did not distinguish the types of milk and dairy products, which might lead to the inconsistent results of no association between dairy consumption and frailty.

There is limited evidence in the literature regarding associations between fruit and vegetable consumption and risk of frailty.[41] In this study, individuals who consumed fresh vegetable (≥2 times/d) (OR=0.42, 95% CI=0.31 – 0.57; OR=0.41, 95% CI=0.23 – 0.72), and fruits (≥1 times/d) (OR=0.64, 95% CI=0.48 – 0.85), with a lower risk of prefrailty and frailty, compared to those consume less fresh vegetables and fruits in model 2. A systematic review showed that fruit and vegetable consumption had a beneficial effect (OR=0.87, 95% CI 0.82-0.92) for the prevention of frailty.[42] In a cross-section study, high fruits and vegetables consumption was found to have a negative association with the frailty in Chinese older adults.[43] Fruit and vegetables consumption exhibited a dose-dependent association with lower short-term frailty risk, with the strongest correlation found at 3 portions of fruit/d and 2 portions of vegetables/d.[44] Similarly, this study reported an inverse dose-response relationship between the baseline fruit consumption and the risk of exhaustion, low physical activity, and slow walking speed among community-dwelling older adults.[44] Fruits and vegetables are sources of antioxidants (e.g., Vitamin C, Vitamin E, b-carotene) and phytochemicals (e.g., polyphenols), which have anti-inflammatory and antioxidant function that can help prevent premature ageing and frailty.[36] However, several studies have also shown mixed results, with a longitudinal study in the C showing a U-shaped association where the lowest and highest fruit and vegetable consumption had higher risks than moderate consumption.[45] Another study in Japan reported that higher fruits (OR=1.24, 95% CI=0.93-1.64) and vegetables (OR=1.16,

95% CI=0.89-1.51) have no significant associated with frailty development.[38] A possible cause is that a high amount of fruit and vegetable consumption may hinder consuming sufficient calories or other important nutrients, such as protein and result in unbalanced, poor-quality diet.[45]

We also found that individuals who consumed nuts (≥2 times/wk) (OR=0.71, 95% CI=0.55 – 0.91; OR=0.52, 95% CI=0.32 – 0.85) with a lower risk of prefrailty and frailty compared to those consume nuts less than 2 times per week in model 2. a cohort study in America showed that higher intakes of peanuts and walnuts, but not peanut butter, were also inversely associated with frailty. And the adjusted HR (95% CI) for consuming ≥5 servings/wk of nuts was 0.80 (0.73, 0.87), as compared with <1 serving/month.46 Another cross-sectional study in China showed that who consumed nuts had a significantly lower risk of frailty compared to non-consumers, and an interaction was observed between nut intake and non-hypertensive populations.[47]

Our study also indicated that higher fried food and salted food was associated with prefrailty risk. However, the significance disappeared with frailty. A meta-analysis indicates fried-food consumption is associated with increased risk of overweight/obesity and hypertension.[48] A cohort researcher in US found that regularly eating fried food is linked with a heightened risk of death from any cause and of heart related death among postmenopausal women. Women who ate one or more servings of fried food a day had an 8% higher risk of death than those who did not eat fried food (OR=1.08, 95% CI=1.01 to 1.16).49 A lower pickled vegetable, was inversely associated with cognitive frailty. In a Chinese longitudinal study involving 4847 participants aged 55 years or older, it was approved that the "starch-rich dietary pattern", in particular salted vegetables and legumes, was positively associated with cognitive decline.[29]

Physical activity and exercise are recognized as the primary strategies to counteract physical impairment related to frailty in the elderly individuals.[50] We also found that higher frequency and duration of walking, exercise, and housework were associated with a lower risk of prefrailty and frailty. A randomized controlled trial demonstrated that a multicomponent exercise program (including aerobic, resistance, and balance training) could reduce frailty and inflammatory biomarkers while improving physical performance in community-dwelling older adults.[51] Another randomized controlled trial showed that high-speed resistance exercise training improved performance significantly in the test for cognitive function (processing speed and executive function), physical function (Short Physical Performance Battery, Timed

Up and Go Test., gait speed), and muscle strength (grip strength, knee extensive strength).[52] Physical activity and exercise could reduce age-related oxidative damage and chronic inflammation, increase autophagy, and improve mitochondrial function, myokine profiles, insulin-like growth factor-1 (IGF-1) signaling pathway, and insulin sensitivity.[50]

There are several limitations in our study. Firstly, the study design was cross-sectional, which may introduce the possibility of reverse causality in analyzing association between major food group and FI. Additionally, our study only focused on the frequency of food groups without considering the quantity. This could be a major flaw in the study, as it is not possible to calculate the intake of some nutrients closely related to frailty, such as calcium, and perform a more in-depth correlation analysis. Furthermore, despite adequate controlling for numerous covariates, there remains some confounding factors that may have arisen from unmeasured variables. For instance, our analysis did not encompass the evaluation of energy intake, data on childbirth for females, and hormone levels.

The strength of this study is the use of the recently developed FI as a frailty screening tool, which simplifies the items of deficits, and references the latest list of the top ten prevalent diseases in the elderly population proposed by the China Research Center on Aging. Our study demonstrates that this FI tool is easy to use and suitable for frailty screening in urban elderly people in China. Additionally, this study is the first to investigate the association between foods consumption frequency and frailty in China. The results provide crucial evidence for the importance of nutrition improvement among older adults in preventing the onset and worsening of frailty.

Conclusions

Among older adults living in urban communities, the consumption of animal-based foods ≥2 times/day, soy products ≥2 times/week, fresh vegetables 2 times/day, and nuts ≥2 times/day is associated with lower risk of prefrailty and frailty. Conversely, Higher frequency of salted products and fried food consumption is positively associated risk of prefrailty. Additionally, walking and exercising are significantly associated with lower risk of prefrailty, while walking and doing housework is significantly associated with lower frailty.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

The authors declare no conflict of interest.

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REFERENCES

1. The Lancet. Population ageing in China: crisis or opportunity? The Lancet. 2022;400:1821. doi: 10.1016/S0140-6736(22)02410-2
2. Dent E, Martin FC, Bergman H, Woo J, Romero-Ortuno R, Walston JD. Management of frailty: opportunities, challenges, and future directions. Lancet. 2019;394:1376-1386. doi: 10.1016/S0140-6736(19)31785-4
3. Zhang Q, Zhao X, Liu H, Ding H. Frailty as a predictor of future falls and disability: a four-year follow-up study of Chinese older adults. Bmc Geriatr. 2020;20:388. doi: 10.1186/s12877-020-01798-z
4. Clegg A, Young J, Iliffe S, Rikkert MO, Rockwood K. Frailty in elderly people. The Lancet. 2013;381:752-62. doi: 10.1016/S0140-6736(12)62167-9.
5. Nikolova S, Heaven A, Hulme C, West R, Pendleton N, Humphrey S, Cundill B, Clegg A. Social care costs for community‐dwelling older people living with frailty. Health Soc Care Community. 2022;30:e804-e811. doi: 10.1111/hsc.13450
6. Mitnitski AB, Mogilner AJ, Rockwood K. Accumulation of deficits as a proxy measure of aging. The Scientific World JOURNAL. 2001;1:323-336. doi: 10.1100/tsw.2001.58
7. Kojima G, Iliffe S, Walters K. Frailty index as a predictor of mortality: a systematic review and meta-analysis. Age Ageing. 2018;47:193-200. doi: 10.1093/ageing/afx162
8. Travers J, Romero-Ortuno R, Langan J, MacNamara F, McCormack D, McDermott C, McEntire J, McKiernan J, Lacey S, Doran P, Power D, Cooney MT. Building resilience and reversing frailty: a randomised controlled trial of a primary care intervention for older adults. Age Ageing. 2023;52:d12. doi: 10.1093/ageing/afad012
9. Battaglia G, Bellafiore M, Bianco A, Paoli A, Palma A. Effects of a dynamic balance training protocol on podalic support in older women. Pilot study. Aging Clin Exp Res. 2010;22:406-411. doi: 10.1007/BF03337736
10. Lorenzo-López L, Maseda A, de Labra C, Regueiro-Folgueira L, Rodríguez-Villamil JL, Millán-Calenti JC. Nutritional determinants of frailty in older adults: a systematic review. Bmc Geriatr. 2017;17:108. doi: 10.1186/s12877-017-0496-2
11. Coelho-Junior HJ, Marzetti E, Picca A, Cesari M, Uchida MC, Calvani R. Protein intake and frailty: a matter of quantity, quality, and timing. Nutrients. 2020;12:2915. doi: 10.3390/nu12102915
12. García-Esquinas E, Rahi B, Peres K, Colpo M, Dartigues J, Bandinelli S, Feart C, Rodríguez-Artalejo F. Consumption of fruit and vegetables and risk of frailty: a dose-response analysis of 3 prospective

cohorts of community-dwelling older adults. Am J Clin Nutr. 2016;104:132-142. doi: 10.3945/ajcn.115.125781

13. Tanaka T, Talegawkar SA, Jin Y, Bandinelli S, Ferrucci L. Association of adherence to the mediterranean-style diet with lower frailty index in older adults. Nutrients. 2021;13:1129. doi: 10.3390/nu13041129
14. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, Seeman T, Tracy R, Kop WJ, Burke G, McBurnie MA; Cardiovascular Health Study Collaborative Research Group. Frailty in older adults: evidence for a phenotype. J Gerontol a Biol Sci Med Sci. 2001;56:M146-M156. doi: 10.1093/gerona/56.3.m146
15. Namazi N, Saneei P, Larijani B, Esmaillzadeh A. Soy product consumption and the risk of all-cause, cardiovascular and cancer mortality: a systematic review and meta-analysis of cohort studies. Food Funct. 2018;9:2576-2588. doi: 10.1039/c7fo01622k
16. Hannah Ritchie PR, Roser M. Meat and dairy production. 2019. https://ourworldindata.org/meat-production#per-capita-milk-consumption [Accessed 2024/04/04]
17. Searle SD, Mitnitski A, Gahbauer EA, Gill TM, Rockwood K. A standard procedure for creating a frailty index. Bmc Geriatr. 2008;8:24. doi: 10.1186/1471-2318-8-24
18. Liu B, Liu Z, Xu Z, Li Y, Han X, Wang J, Shi H, Zhang J. Reliability and validity of comprehensive geriatric assessment scale for communitydwelling elderly. Chin J Mult Organ Dis Elderly. 2022;10:741-748. doi: 10.11915/j.issn.1671-5403.2022.10.161
19. Liu B, Liu Z, Xu Z, Han X, Wang J, Shi H, Zhang J. Development of comprehensive geriatric assessment scale for the elderly in urban communities in China based on Delphi method. Chin J Prev Contr Chron Dis. 2023;31:60-65. doi: 10.16386/j.cjpccd.issn.1004-6194.2023.01.014
20. Kulminski AM, Ukraintseva SV, Kulminskaya IV, Arbeev KG, Land K, Yashin AI. Cumulative deficits better characterize susceptibility to death in elderly people than phenotypic frailty: lessons from the cardiovascular health study. J Am Geriatr Soc. 2008;56:898-903. doi: 10.1111/j.1532-5415.2008.01656.x
21. Chen LK, Woo J, Assantachai P, Auyeung TW, Chou MY, Iijima K, Jang HC, Kang L, Kim M, Kim S, Kojima T, Kuzuya M, Lee JSW, Lee SY, Lee WJ, Lee Y, Liang CK, Lim JY, Lim WS, Peng LN, Sugimoto K, Tanaka T, Won CW, Yamada M, Zhang T, Akishita M, Arai H. Asian working group for sarcopenia: 2019 consensus update on sarcopenia diagnosis and treatment. J Am Med Dir Assoc. 2020;21:300-307. doi: 10.1016/j.jamda.2019.12.012
22. Li C, Kang B, Zhang T, Gu H, Song P, Chen J, Wang X, Xu B, Zhao W, Zhang J. Dietary pattern and dietary energy from fat associated with sarcopenia in community-dwelling older Chinese people: a cross-sectional study in three regions of China. Nutrients. 2020;12:3689. doi: 10.3390/nu12123689
23. Kant AK, Schatzkin A, Harris TB, Ziegler RG, Block G. Dietary diversity and subsequent mortality in the first national health and nutrition examination survey epidemiologic follow-up study. Am J Clin Nutr. 1993;57:434-440. doi: 10.1093/ajcn/57.3.434

24. Fan M, Lyu J, He P. Chinese guidelines for data processing and analysis concerning the International Physical Activity Questionnaire[J]. Chin J Epidemiology. 2014, 35: 961-964. doi: 10.3760/cma.j.issn.0254-6450.2014.08.019
25. Fan J, Yu C, Guo Y, Bian Z, Sun Z, Yang L, Chen Y, Du H, Li Z, Lei Y, Sun D, Clarke R, Chen J, Chen Z, Lv J, Li L; China Kadoorie Biobank Collaborative Group. Frailty index and all-cause and cause-specific mortality in Chinese adults: a prospective cohort study. Lancet Public Health. 2020;5:e650-e660. doi: 10.1016/S2468-2667(20)30113-4
26. He B, Ma Y, Wang C, Jiang M, Geng C, Chang X, Ma B, Han L. Prevalence and risk factors for frailty among community-dwelling older people in China: a systematic review and meta-analysis. J Nutr Health Aging. 2019;23:442-450. doi: 10.1007/s12603-019-1179-9
27. Hajek A, Kretzler B, König H. Prevalence of prefrailty and frailty among older adults in Germany: a systematic review, meta-analysis and meta-regression. Front Med (Lausanne). 2022;9:870714. doi: 10.3389/fmed.2022.870714
28. Bennett S, Song X, Mitnitski A, Rockwood K. A limit to frailty in very old, community-dwelling people: a secondary analysis of the Chinese longitudinal health and longevity study. Age Ageing. 2013;42:372-377. doi: 10.1093/ageing/afs180
29. Huang W, Huang Y, Lee M, Chang H, Doong J. Frailty severity and cognitive impairment associated with dietary diversity in older adults in Taiwan. Nutrients. 2021;13:418. https://doi.org/10.3390/nu13020418
30. Struijk EA, Fung TT, Sotos-Prieto M, Rodriguez-Artalejo F, Willett WC, Hu FB, Lopez-Garcia E. Red meat consumption and risk of frailty in older women. J Cachexia Sarcopenia Muscle. 2022;13:210-219. doi: 10.1002/jcsm.12852
31. Coelho-Júnior H, Rodrigues B, Uchida M, Marzetti E. Low protein intake is associated with frailty in older adults: a systematic review and meta-analysis of observational studies. Nutrients. 2018;10:1334. doi: 10.3390/nu10091334
32. Coelho-Júnior H, Milano-Teixeira L, Rodrigues B, Bacurau R, Marzetti E, Uchida M, Uchida M. Relative protein intake and physical function in older adults: a systematic review and meta-analysis of observational studies. Nutrients. 2018;10:1330. doi: 10.3390/nu10091330
33. Mendonça N, Kingston A, Granic A, Jagger C. Protein intake and transitions between frailty states and to death in very old adults: the newcastle 85+ study. Age Ageing. 2020;49:32-38. doi: 10.1093/ageing/afz142
34. Yamaguchi M, Yamada Y, Nanri H, Nozawa Y, Itoi A, Yoshimura E, Watanabe Y, Yoshida T, Yokoyama K, Goto C, Ishikawa-Takata K, Kobayashi H, Kimura M; Kyoto-Kameoka Study Group. Association between the frequency of protein-rich food intakes and Kihon-Checklist frailty indices in older Japanese adults: the Kyoto-Kameoka study. Nutrients. 2018;10:84. doi: 10.3390/nu10010084
35. Prokopidis K, Mazidi M, Sankaranarayanan R, Tajik B, Mcardle A, Isanejad M. Effects of whey and soy protein supplementation on inflammatory cytokines in older adults: a systematic review and meta-analysis. Br J Nutr. 2022;129(5):759-770. doi: 10.1017/S0007114522001787

36. Khodarahmi M, Foroumandi E, Asghari JM. Effects of soy intake on circulating levels of tnf-alpha and interleukin-6: a systematic review and meta-analysis of randomized controlled trials. Eur J Nutr. 2021;60:581-601. doi: 10.1007/s00394-020-02458-z
37. Ni Lochlainn M, Cox NJ, Wilson T, Hayhoe RPG, Ramsay SE, Granic A, Isanejad M, Roberts HC, Wilson D, Welch C, Hurst C, Atkins JL, Mendonça N, Horner K, Tuttiett ER, Morgan Y, Heslop P, Williams EA, Steves CJ, Greig C, Draper J, Corish CA, Welch A, Witham MD, Sayer AA, Robinson S. Nutrition and frailty: opportunities for prevention and treatment. Nutrients. 2021;13:2349. doi: 10.3390/nu13072349
38. Otsuka R, Tange C, Tomida M, Nishita Y, Kato Y, Yuki A, Ando F, Shimokata H, Arai H. Dietary factors associated with the development of physical frailty in community-dwelling older adults.J Nutr Health Aging. 2019;23:89-95. doi: 10.1007/s12603-018-1124-3
39. Lana A, Rodriguez-Artalejo F, Lopez-Garcia E. Dairy consumption and risk of frailty in older adults: a prospective cohort study. J Am Geriatr Soc. 2015;63:1852-1860. doi: 10.1111/jgs.13626
40. Zhen L, Shaojie P, Yuqian L, Qingqing M, Lixiang L, Jian Z. Consumption status of dairy products in Chinese aged 60 and above in 2010-2012. J Hygiene Res. 2016;45:708-713. doi: 10.19813/j.cnki.weishengyanjiu.2016.05.004
41. Kojima G, Avgerinou C, Iliffe S, Jivraj S, Sekiguchi K, Walters K. Fruit and vegetable consumption and frailty: a systematic review. J Nutr Health Aging. 2018;22:1010-1017. doi: 10.1007/s12603-018-1069-6
42. Kojima G, Avgerinou C, Iliffe S, Jivraj S, Sekiguchi K, Walters K. Fruit and vegetable consumption and frailty: a systematic review. J Nutr Health Aging. 2018;22:1010-1017. doi: 10.1007/s12603-018-1069-6
43. Gao J, Jia Y, Dai J, Fu H, Wang Y, Yan H, Zhu Y, Nie X. Association of fruit and vegetable intake and frailty among Chinese elders: a cross-sectional study in three cities. J Nutr Health Aging. 2019;9:890-895. doi: 10.1007/s12603-019-1236-4
44. García-Esquinas E, Rahi B, Peres K, Colpo M, Dartigues JF, Bandinelli S, Feart C, Rodríguez-Artalejo F. Consumption of fruit and vegetables and risk of frailty: a dose-response analysis of 3 prospective cohorts of community-dwelling older adults. Am J Clin Nutr.. 2016;104:132-142. doi: 10.3945/ajcn.115.125781
45. Kojima G, Iliffe S, Jivraj S, Walters K. Fruit and vegetable consumption and incident prefrailty and frailty in community-dwelling older people: the English longitudinal study of ageing. Nutrients. 2020;12:3882. doi: 10.3390/nu12123882
46. Wang R, Hannan MT, Wang M, Schwartz AW, Lopez-Garcia E, Grodstein F. Long-term consumption of nuts (including peanuts, peanut butter, walnuts, and other nuts) in relation to risk of frailty in older women: evidence from a cohort study. J Nutr. 2023;153:820-827. doi: 10.1016/j.tjnut.2023.01.003
47. Yang Y, Zhang D, Yuan G, Wu Y, Huang X. Association between nut consumption and frailty in the elderly: a large sample cross-sectional study. J Hum Nutr Diet. 2023;36:1845-1856. doi: 10.1111/jhn.13208

47. Qin P, Liu D, Wu X, Zeng Y, Sun X, Zhang Y, Li Y, Wu Y, Han M, Qie R, Huang S, Zhao Y, Feng Y, Yang X, Liu Y, Li H, Zhang M, Hu D, Hu F. Fried-food consumption and risk of overweight/obesity, type 2 diabetes mellitus, and hypertension in adults: a meta-analysis of observational studies. Crit Rev Food Sci Nutr. 2022;62:6809-6820. doi: 10.1080/10408398.2021.1906626
48. Kmietowicz Z. Fried food linked to increased risk of death among older us women. BMJ. 2019:364:l362. doi: 10.1136/bmj.l36250
49. Angulo J, El Assar M, álvarez-Bustos A, Rodríguez-Mañas L. Physical activity and exercise: strategies to manage frailty. Redox Biol. 2020;35:101513. doi: 10.1016/j.redox.2020.101513
50. Sadjapong U, Yodkeeree S, Sungkarat S, Siviroj P. Multicomponent exercise program reduces frailty and inflammatory biomarkers and improves physical performance in community-dwelling older adults: a randomized controlled trial. Int J Environ Res Public Health.. 2020;17:3760. doi: 10.3390/ijerph17113760
51. Apóstolo J, Cooke R, Bobrowicz-Campos E, Santana S, Marcucci M, Cano A, Vollenbroek-Hutten M, Germini F, D'Avanzo B, Gwyther H, Holland C. Effectiveness of interventions to prevent pre-frailty and frailty progression in older adults: a systematic review. JBI Database System Rev Implement Rep. 2018;16:140-232. doi: 10.11124/JBISRIR-2017-003382.

Table 1. Characteristics of participants

	Male (n=584)	Female (n=599)	Total (n=1183)
Sociodemographics			
Age, median (SD), years	71.3 (4.7)	71.4 (4.5)	71.4 (4.6)
65-69	251	229	480 (40.6)
70-74	180	217	397 (33.6)
75-79	108	118	226 (19.1)
80 and above	45	35	80 (6.8)
Education			
Primary or below	144	280	424 (35.8)
Secondary school	358	292	650 (55.0)
College or above	82	27	109 (9.2)
Marital status			
Married	549	477	1026 (86.7)
Death of a spouse/unmarried	35	122	157 (13.3)
Living conditions			
Living with others	562	532	1094 (92.5)
Living alone	22	67	89 (7.5)
Profession before retired			
Farmer	82	323	405 (34.2)
Worker	210	97	307 (26.0)
Others	292	179	471 (39.8)
Health care insurance			
Basic medical insurance or state medicine for urban workers	503	308	811 (68.6)
Basic medical insurance for urban and rural residents	81	291	372 (31.5)
Pension income			
<2000	74	321	395 (33.4)
2001-4000	107	164	271 (22.9)
4001-6000	210	95	305 (25.8)
>6000	193	19	212 (17.9)
Region			
Jiangbei district, Chongqing	290	305	595 (50.3)
Dongying, Shandong	294	294	588 (49.7)
Frailty			
Robust	358	282	640 (54.1)
Prefrailty	190	272	462 (39.1)
Frailty	36	45	81 (6.9)

Table 2. Frequency of major foods group consumption (mean±SD)

	Robust (n=640)	Prefrail (n=462)	Frail (n=81)	Total (n=1183)	χ^2	*p*
DDS (Score)	12.3±2.2	12.0±2.4	12.1±2.1	12.2±2.3	3.23	0.20
Frequency of food groups (times/wk)						
Cereals	18.9±3.8	18.2±4.6	17.6±5.6	18.5±4.3	6.55	0.04
Coarse cereals	8.0±6.4	7.3±5.6	9.4±6.8	7.8±6.2	7.86	0.02
Animal-based foods	16.1±5.2	14.3±5.4	14.2±6.7	15.3±5.5	40.69	<0.01
Meats	8.2±4.4	6.6±4.2	5.9±4.6	7.4±4.4	46.33	<0.01
Seafood	1.2±1.1	1.2±1.3	1.1±1.2	1.2±1.2	2.75	0.25
Eggs	6.8±2.6	6.5±2.2	7.2±3.4	6.7±2.5	2.58	0.27
Soy products	2.5±2.3	2.1±1.8	2.0±1.8	2.3±2.1	13.74	<0.01
Dairy products	4.7±3.3	4.8±3.3	4.4±3.7	4.7±3.3	1.25	0.54
Fresh vegetables	13.2±3.9	12.6±4.6	12.8±4.7	12.9±4.2	5.52	0.06
Fruits	6.4±3.6	6.6±4.2	7.0±4.0	6.5±3.9	1.35	0.51
Salted products	2.9±4.0	3.6±4.5	4.4±4.8	3.3±4.3	8.71	0.01
Nuts	3.0±3.0	2.8±3.0	2.5±3.1	2.9±3.0	9.25	<0.01
Fried food	0.3±0.6	0.3±0.5	0.2±0.4	0.3±0.6	9.56	<0.01
Bread, cakes and desserts	1.5±2.0	1.7±2.6	1.5±2.2	1.6±2.3	2.90	0.23

Table 3. Frequency and duration of physical activities (mean±SD)

	Robust (n=640)	Prefrail (n=46 2)	Frail (n=81)	Total (n=1183)	χ^2	p
Frequency (times/wk)						
Outdoor activity	9.1±4.9	9.0±5.2	8.4±4.5	9.1±5.0	0.89	0.64
Walk	8.3±4.6	8.2±5.5	7.1±5.5	8.2±5.0	3.89	0.14
Exercise	2.1±3.7	1.0±3.3	0.5±2.1	1.6±3.5	46.82	<0.01
Social activity	3.2±3.9	3.2±5.4	2.3±4.0	3.1±4.6	8.93	0.01
Housework	14.8±6.6	14.8±7.7	11.3±8.7	14.5±7.3	13.18	<0.01
Duration (min/wk)						
Outdoor activity	538.9±391.5	550.3±475.6	494.2±429.9	540.3±428.7	2.70	0.26
Walk	453.9±318.8	447.0±393.4	345.3±314.9	443.8±350.3	10.70	<0.01
Exercise	116.0±221.8	56.7±210.9	27.0±103.0	86.8±213.8	53.82	<0.01
Social activity	193.4±293.2	192.8±351.2	145.4±303.9	189.9±317.8	9.69	<0.01
Housework	601.8±379.0	593.0±379.2	487.3±412.9	591.6±381.7	6.54	0.04

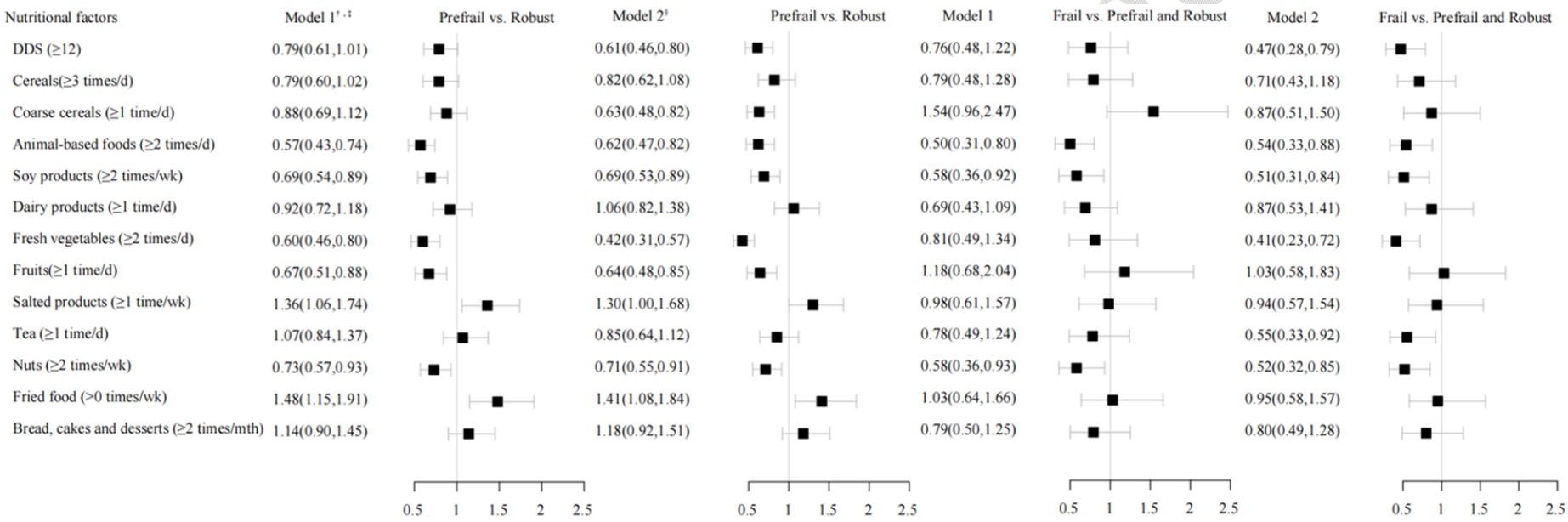

Figure 1. Associations between foods consumption and odds ratios for prefrail and frail. †Values presented as ORs (95% CIs) unless otherwise indicated. ‡Model 1: Model adjusted for age, gender; §Model 2: Model 1 + additional adjustment for education, marital status, pension income, drinking history, smoking history, dietary supplements, physical activity level.

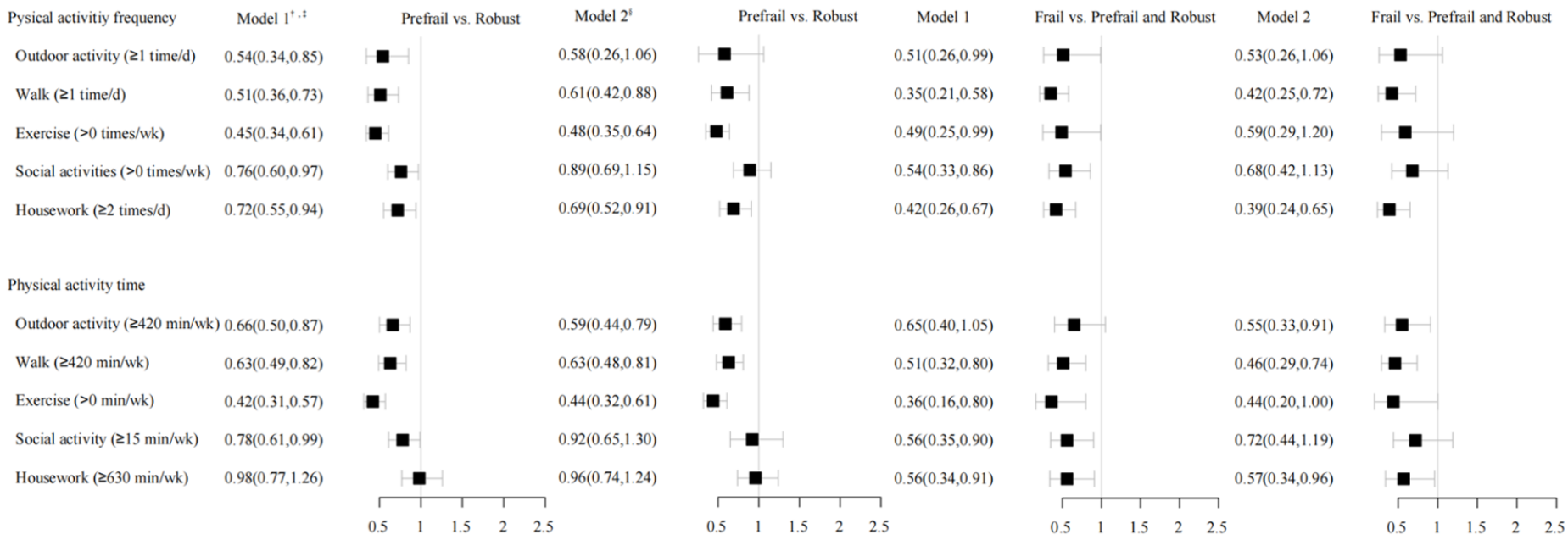

Figure 2. Associations between physical activity and odds ratios for prefrail and frail. †Values presented as ORs (95% CIs) unless otherwise indicated. ‡Model 1: Model adjusted for age, gender; §Model 2: Model 1 + additional adjustment for education, marital status, pension income, drinking history, smoking history, dietary supplements, dietary diversity.